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U.S. Department of Transportation
Federal Aviation Administration

DRAFT

Advisory Circular

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Subject: Advisory Material for the evaluation of the Certification Basis of Changed Aeronautical Products

Date:
Initiated By: AIR-110

AC No: 21.101-XX
Change:

1. PURPOSE. This advisory circular (AC) provides guidance for understanding compliance with certain regulations pertaining to changes to type certificates. An applicant seeking approval of a changed aeronautical product may follow this guidance in developing his own arguments as to the appropriate certification basis. An applicant may also develop arguments without using the guidance in this AC.

2. RELATED FAR SECTIONS.

a. Section 21.17. Designation of applicable regulations.

b. Section 21.19. Changes requiring a new type certificate.

c. Section 21.93. Classification of changes in type design.

d. Section 21.101. Designation of applicable requirements.

e. Section 21.115. Applicable requirements.

3. EXPLANATION OF TERMS.

a. Earlier Regulations. The regulations as amended prior to those in effect at the date of the application for the change, but not earlier than either the corresponding regulations incorporated by reference in the type certificate or the corresponding retroactive regulations in §§ 23.2, 25.2, 27.2, or 29.2. Compliance with an earlier regulation could also require compliance with other regulations that the Administrator finds to be directly related.

b. Later Regulations. The applicable regulations that are in effect at the date of the application for the change.

4. APPENDICES. The appendices are:

a. Appendix 1 Classification of Changes/Examples: Further explanation and examples

b. Appendix 2 Safety Benefit-Resource Evaluation: A process recommended by the Aviation Rulemaking Advisory Committee

c. Appendix 3 Example of Service Experience Being Used for Evaluating the Certification Basis for a Changed Product: Further explanation and examples

5. BACKGROUND. In an attempt to enhance the level of safety of changed type certificated products, Amendment 21-XX has created a new procedure for establishing the certification basis for a change; a very comprehensive innovation within the culture of the type certification activity. Sections 21.17, 21.19, and 21.101 contain regulations that determine when an applicant may make a change in a type design through an amended or supplemental type certificate and when an applicant must apply for a new type certificate. The significant change in the regulations involves those changes to type certificated products that are not considered substantial under § 21.19. Previously, these changes could comply with the regulations incorporated by reference in the type certificate. By contrast, in accordance with amendment 21-XX, these changes require compliance with the regulations in effect at the date of the application or, depending on certain exceptions, with earlier amendments to the applicable regulations, but not earlier than the regulations incorporated by reference in the type certificate plus any applicable retroactive regulations. These procedures are applicable to changes approved under either an amended or supplemental type certificate. The most important difference between the regulations as amended by Amendment 21-XX and previous regulations is that under Amendment 21-XX, the starting point for

determining the certification basis for an amended or supplemental type certificate is the regulations in effect at the date of the application for the change rather than those regulations incorporated by reference in the type certificate.

6. SPECIAL CONDITIONS. Section 21.101(c) allows for the application of special conditions to a proposed change of a type certificated product for a novel or unusual design feature. In order to achieve the highest level of safety practicable, § 21.101(c) requires that the special conditions provide a level of safety equal to that established by the regulations in effect at the date of the application for the change. The inclusion of special conditions does not relieve the applicant from justifying not complying with the later regulations.

7. EFFECTIVE PERIOD FOR AN APPLICATION FOR A CHANGE. Section 21.101(d) contains an effective period for an application for a change to a type certificated product: 5 years for a change to a transport category aircraft and 3 years for a change to all other type certificated products. These requirements parallel those for an application for a new type certificate.

8. LISTING OF THE CERTIFICATION BASIS. The established certification basis for a change is presented in the type certificate data sheet. The airworthiness standards can be listed starting with the latest amendment level with which the changed product complies. Then the more recent amendment levels used for the certification basis for the change can be added, identifying them with the change.

9. METHODOLOGY.

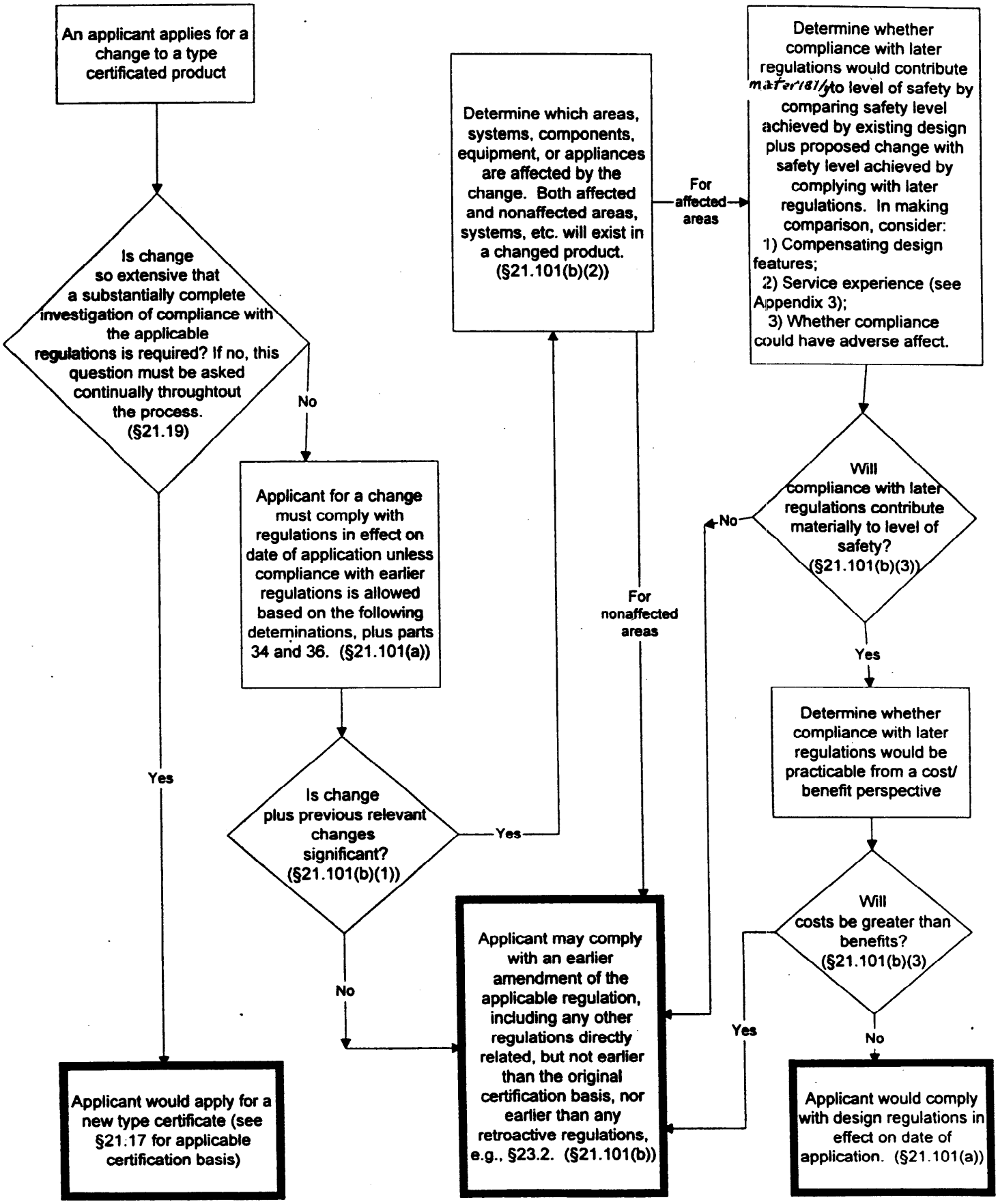
a. Applicability The procedure is applicable to any category of type certificated products, and is applicable equally to an applicant for a supplemental type certificate as for an amended type certificate. All applicants for the same alteration to the same product should have to comply with the same regulations.

b. Extent of Change It is recommended that initially each design change should be evaluated individually to determine its importance in relation to the product as a whole. After this evaluation, the various design changes should be considered in combination. In each situation, the extent of the changes needs to be considered in relation to previous models, taking into account the certification background of the models of the product to help determine the applicability of §§ 21.19 and 21.101 to the changed product.

c. Practicability A procedure, presented in Appendix 2, is based on results from accident and incident data of transport category airplanes used in airline service. It describes a process that was developed with the intention of using it to determine the practicability of a changed product, in accordance with § 21.101(b)(3). This appendix is included in the AC for information purposes only.

d. Flow Chart The methodology for establishing the certification basis for a change to a type design is set forth in the flowchart presented in Figure 1. When following this procedure, the applicant should start with the later regulation and work backwards in time to identify the amendment
level of the regulation to be used for the certification basis. The remainder of this AC and its appendices elaborate on this flowchart.

FIGURE 1: FLOWCHART FOR EVALUATING THE CERTIFICATION BASIS FOR CHANGED AERONAUTICAL PRODUCTS



10. CHANGES THAT REQUIRE A NEW TYPE CERTIFICATE (§ 21.19).

a. Determining Substantial Change. Section 21.19 requires that each person who proposes to change a product must apply for a new type certificate if the Administrator finds that the proposed change in design, power, thrust, or weight is so extensive that a substantially complete investigation of compliance with the applicable regulations is required. Appendix 1 contains examples of changes that would be considered substantial and normally would require a new type certificate. If a new type certificate is required, the product must comply with the regulations in effect at the date the applicant applies. Application of § 21.19 would depend upon an evaluation of whether the proposed change in "design, power, thrust, or weight" would necessitate a substantially complete investigation of the compliance of the changed product.

b. Ongoing Determination. The question of whether a change is extensive enough to warrant a new type certificate must be addressed at the beginning of the process. While the question for a substantial change is not repeated in each step described in this AC, as a practical matter, both the applicant and the FAA must revisit this issue throughout the process. If at any point it becomes clear that the proposed change is a substantial change the process ceases to be an amendment process and becomes a new type certificate process under § 21.19.

11. EVALUATION OF THE CERTIFICATION BASIS.

a. General. Section 21.101(a)(1) requires that an applicant for a change to a type certificate must comply with the applicable airworthiness regulations in effect at the date of the application for the change. However, § 21.101(b), provides exceptions permitting the applicant to comply with earlier regulations. Thus, an applicant for an amended or supplemental type certificate who can show that his design complies with one of the exceptions may comply with earlier regulations.

b. Procedures for Evaluating the Certification Basis. If the change to the product falls within one of the exceptions provided by § 21.101(b) and described in paragraph (c) below, an applicant may show that the changed product complies with an earlier amendment to the regulations and any other regulations that the Administrator finds is directly related. However, the earlier amendment may not precede, (1) the applicable retroactive regulations, or (2) those regulations incorporated by reference in the type certificate. It is the applicant's responsibility to substantiate compliance with exceptions to the later regulations for the proposed change. The determination of which regulations are applicable to the change will be based on the applicant's arguments and the FAA's acceptance of them, as explained in this section of this AC.

c. Exceptions that would allow compliance with earlier regulations. Section 21.101(b) allows compliance with earlier regulations under one or more of the exceptions listed below. Further elaboration of these exceptions is presented in sections 12 through 15 of this AC.

(1) Non -significant changes. A change the effect of which, combined with all previous changes, the Administrator finds is nonsignificant;

(2) Items not affected. Each area, system, component, equipment, or appliance that the Administrator finds is not affected by the change; and

(3) Affected items where compliance doesn't contribute materially to the level of safety or is impractical. Each area, system, component, equipment, or appliance that is affected by the change, for which the Administrator also finds that compliance with a regulation described in § 21.101(a)(1) would not contribute materially to the level of safety of the changed product or would be impractical.

d. Methodology for evaluating earlier regulations for the certification basis. The methods to be used in determining whether an applicant for an amended or supplemental type certificate will be allowed to comply with earlier regulations depends on which exceptions are applicable. The process is deliberative between the

applicant and the FAA. At the end of that process, the FAA prescribes the certification basis. The appendices to this AC contain guidance material for the applicant and the FAA on whether a change is significant; whether an area, system, component, equipment, or appliance is affected; and whether service experience is applicable. The guidance material in the appendices is not intended to provide a definitive conclusion because the final determination is largely based on analysis of the arguments presented. The applicant's arguments would be used to aid the FAA to arrive at the certification basis.

12. DETERMINATION OF SIGNIFICANCE. Section 21.101(b)(1) allows compliance with earlier regulations for a change the effect of which, combined with all previous relevant changes and their certification bases, the Administrator finds is nonsignificant. The applicant must provide arguments to substantiate compliance with the exceptions in the rule. Included in non-significant changes are changes that do not modify the general characteristics of the product, that is, (1) the general configuration and the principles of construction are retained; and (2) the assumptions used for certification of the basic product remain valid and the results can be extrapolated to cover the changed product.

13. UNAFFECTED ITEMS. Section 21.101(b)(2) allows an applicant for an amended type certificate to comply with earlier amendments for each area, system, component, equipment, or appliance that the Administrator finds is not affected by the change. That is, there is not a need for recertification.

a. Areas. The term "areas" as used in the regulation and this AC is intended to cover general characteristics of an aircraft, such as performance, handling qualities, emergency provisions, fire protection, structural integrity, and crashworthiness. Each area of a product, therefore, must be reviewed relevant to a proposed change to that product. For example, adding a fuselage plug would require a review of how the change affects performance and handling qualities of the airplane.

b. Physical Items. Physical items cover systems, equipment, components, and appliances. Both hardware and software are included. In determining whether an item is affected or unaffected, it may be necessary to distinguish between principal and secondary changes. An example of a principal change is adding a fuselage plug that would affect handling qualities and performance of the airplane. The lengthening of the various circuits and adding seats with overhead bins, associated with adding the fuselage plug, however, would be considered secondary changes. Normally, an item involved in a secondary change would not be considered an affected item, although this conclusion should not be assumed.

14. NOT CONTRIBUTE MATERIALLY TO THE LEVEL OF SAFETY. Section 21.101(b)(3) allows compliance with an earlier regulation if compliance with the later regulation would not contribute materially to the level of safety of the changed product. To show that compliance with the required later regulation would not contribute materially to the level of safety, the applicant would have to show that the level of safety achieved by the existing design plus the proposed change certificated to an earlier regulation would provide an equivalent level of safety to that which would be achieved by complying with the required later regulation for the proposed change. In making this evaluation, minimally, the applicant should consider the following:

a. Consistency of Design Requirements. The consistency of a design may be considered a compensating design feature. For example, when a fuselage plug is added, additional seats and overhead bins are likely to be installed. An additional door and an extended lower cargo hold may also be incorporated. These additional seats, bins, door, and lower deck cargo hold may be identical to existing ones. The structural plug may also be identical to the existing structure. In this case, applying the later regulations to the changed parts would not necessarily improve the level of safety compared to that before the change; the use of earlier regulations should be permitted.

b. Service experience. Relevant service experience, reflecting the history of an existing component, may be used to justify the use of the existing certification basis in lieu of later regulations if the service experience demonstrates a level of safety similar

to that achievable by complying with the later regulations. Service experience may be shown for each area, system, component, equipment, or appliance that is being changed, or that is directly affected by the change. The changed design must be sufficiently similar to the existing design that the service history is applicable. Appendix 3 contains additional guidance on the use of relevant service experience.

c. Potential Adverse Effect On Safety. If an applicant can show that compliance with a particular later regulation, notably when it necessitates a redesign, could potentially have an adverse effect on the level of safety in terms of performance or reliability, the applicant most likely would be allowed to comply with an earlier regulation. This is an aspect of determining whether compliance with the later regulation would materially contribute to the level of safety.

d. Corrective Or Clarifying Amendments. Compliance with an amended regulation normally would not be required if the amendment was made only to correct, consolidate, or clarify the text of an existing regulation. Generally, these amendments would not add a substantive requirement.

15. IMPRACTICAL. Section 21.101(b)(3) allows compliance with an earlier regulation if the applicant can show that compliance with the later regulation is impractical. Compliance would be considered impracticable if the increase in the level of safety that would be achieved by complying with later regulations is not commensurate with the cost of achieving that increase. Where compliance with a later regulation would prompt a redesign, the cost of redesigning other parts of the product to accommodate this redesign also would be considered, along with the cost associated with this compliance.

John K. McGrath
Manager, Aircraft Engineering Division

APPENDIX 1 - CLASSIFICATION OF CHANGES/EXAMPLES

1. INTRODUCTION. This Appendix is provided to assist in deciding what might be regarded as a substantial, significant, or non-significant change to a type certificated aeronautical product as defined in the main text of this advisory circular. Note that the appendix headings are related to the changes themselves rather than the perceived extent of those changes. The terms "normally" and "typically" are used to indicate that judgment is required for particular cases.

2. AIRPLANES.

a. Airframe Changes.

(1) Typically the following design changes alone could be regarded as being substantial:

(i) Change from a high wing to a low wing, or vice versa;

(ii) Change of empennage configuration for larger airplanes (cruciform vs 'T' or 'V' tail); and

(iii) Complete repositioning of engines (tail to wing, etc);

(2) Alternatively, in isolation, the following design changes could typically be regarded as significant rather than substantial:

(i) Fuselage length change;

(ii) Fuselage diameter change;

(iii) A design change that appreciably affects the characteristics of the primary load bearing structure;

(iv) Change to wing sweepback of less than approximately 10 degrees;

(v) Undercarriage configuration:

(A) retractable vs fixed
(B) tailwheel vs tricycle
(C) installation of skis/floats;

(vi) The introduction of a cargo door on an existing aircraft;

(vii) The introduction of a cabin pressurization system; and

(viii) A design change that appreciably alters structural crash worthiness features;

b. Principles of Propulsion. A change in the principle of propulsion from either a reciprocating or turbopropeller engine to a turbojet will normally be regarded as substantial and require a new TC. This will typically be due to the different air mass flow effects on the aircraft; for example, propeller slip-stream benefits on elevator effectiveness in critical flight conditions.

c. Engines and Propellers. Here the complexity which results from design changes needs to be considered very carefully when coming to a conclusion as to whether the change is substantial or significant. When there is a reduction in the number of engines on an airplane, say from 3 to 2 and the related changes are small, a new TC is unlikely to be required. Similarly, a new type certificate would not be required for a change to replace reciprocating engines with the same number of turbopropeller engines. On the other hand increased airplane complexity will generally result from an increase in the number of engines, particularly from one engine to two, and hence will normally be regarded as a substantial design change. Finally, the installation of an

alternative engine using the same principles of operation that does not greatly alter power limitations and which has a minimum number of installation changes could be regarded as nonsignificant.

d. Materials. Use of new types of material, such as composites, for primary structure would normally be assessed as a significant change.

e. Weight. A maximum take-off weight (MTOW) increase of more than 50% would normally be regarded as being a substantial change.

A MTOW increase of less than 20% by itself, would not normally be considered to be more than significant. An increase of less than 5% is likely to be regarded as being nonsignificant.

f. Power or Thrust. An overall power/thrust increase of more than 50% would normally be regarded as being a substantial change, whereas an increase of less than 20%, by itself, would not be considered to be greater than significant. An increase of less than 5% is likely to be regarded as nonsignificant.

(1) If the change involves fewer engines, the change in power or thrust at a particular engine location should also be considered as well as the change in total power or thrust.

(2) If the additional power is simply used to enhance high altitude or hot day performance then the change is likely to be nonsignificant.

Note: Weight and power/thrust variables (paragraphs 2(e) and (f)) are obviously interrelated and should be referenced back to the original model.

g. Systems.

(1) General. As a general guide, the classification of substantial and significant will depend upon:

(i) Airplane capability enhancement;

(ii) New technologies employed; and

(iii) Certification basis of the airplane.

(2) Flight Controls. A change in the flight control concept for an aircraft, for example to fly by wire and side-stick, would, in isolation, normally be regarded as a significant change.

(3) Avionics. Examples of individual significant avonic changes are:

(i) A major flight deck update;

(ii) Installation of avionics equipment where operational credit is to be taken for its presence in an aircraft. For example, a heads-up display; and

(iii) Introduction of autoland.

(4) Avionics. Examples of individual non-significant avonic changes are:

(i) A general avionics equipment change, including installation of a new system such as GPS for information purposes, where no credit is taken for it as an aid; and

(ii) An alternative autopilot.

(5) Brakes. An alternative type of wheel brakes would be regarded as being nonsignificant.

h. Cabin. The most prominent changes are likely to be those which have an adverse effect on the emergency egress capability of an airplane; for example, types and number of emergency exits, increase in passenger capacity, etc. Changes of this nature would usually be regarded as significant design changes.

i. Flight Crew. A reduction in flight crew numbers which necessitates a complete cockpit rearrangement and/or an increase in pilot workload would amount to a significant change.

j. Operating Envelope/Capability. Any marked expansion of an aircraft's operating envelope or operating capability, for example the following items, would normally be seen as significant changes:

(1) An increase in maximum altitude to above 41,000 ft; and

(2) Approval for flight in known icing conditions.

k. Auxiliary Power Unit (APU) Installation. Typically the introduction of an APU installation would be categorized as a significant change.

3. ROTORCRAFT. The same general principles outlined in paragraph 2 above would also apply to rotorcraft. Additionally:

a. A change to the number of main rotors would be considered as a substantial change.

b. A change to the number of main rotor blades, the nature of the blades, or the method of control, would normally be regarded individually as significant. In combination they may well warrant a substantial classification.

c. Changes in the principles of directional control (e.g. tail rotor to ducted air) would be regarded as significant. Other changes, such as the use of exhaust to unload the tail rotor, would be considered nonsignificant.

d. A change which involves the introduction of a twin engine installation in place of a single engine would normally be classified as significant.

4. ENGINES. In addition to the general points included in paragraphs 2 and 3 above, the following items highlight specific topics which should be considered in relation to engine type certification:

a. Turbine Engines.

(1) Rotor Stages. Unless associated with a marked corresponding increase in power or thrust (normally>30%), a change to the number of compressor or turbine stages would normally be regarded as a significant, rather than substantial, design change. An exception might be the addition of a fan stage to an existing turbine engine.

(2) Fixed Turbine vs Free-turbine in a Shaft Output Engine. A change of this nature would normally necessitate other significant modifications (engine control modes and systems, additional shafts and bearings, lubrication system changes etc.) the combination of which is likely to be regarded as a substantial design change package.

(3) Fuel Control System. A change to the fuel control system type would only be considered significant if it required a major reassessment of the engine and control system failure analysis, or in the case of an engine already approved for extended range two engine aircraft operations (ETOPS) the reliability analysis. Thus a change from one hydromechanical design to another would normally be nonsignificant, since although the failure modes and effect analysis (FMEA) would need to be redone there is no fundamental philosophical change, whereas to go from a hydromechanical to a

dual channel full authority digital electronic control (FADEC) with no manual backup would almost certainly be significant. Calibration adjustments and the provision of various limits to suit specific aircraft installations within the existing engine approval are nonsignificant.

(4) Structural Design Changes. There are design changes which appear to be almost nonsignificant but which in reality are significant. This is when the change is in the engine structure or basic mechanical design but is not readily apparent. A good example is when a separately bladed fan is replaced by an integral unit. This would require a reassessment of bird ingestion capability at the very least. A structural design change between integral and built-up rotor stages might be considered as significant.

b. Reciprocating Engines.

(1)Number of Cylinders. A change to the number of cylinders would normally be considered as substantial.

(2) Principle of Operation. Conversion from spark ignition to compression ignition would normally be regarded as a substantial change, because of the major changes in component strength required by the mode of operation.

(3) Supercharging. Supercharging by either mechanical or exhaust-driven means will not normally be regarded as a substantial change where the feature is used to enhance hot day or high altitude performance. For example, the addition of a turbocharger should not have a marked effect unless a dramatic increase in (sea level, standard day) power is sought. If however the objective is a large increase in power (see also paragraph 4(a)), the change might be classified as substantial.

(4) Fuel Control System. Changes in the fuel control system, such as float carburetor to pressure carburetor, carburetor to fuel injection, electronic fuel controls (FADEC), etc., could be considered significant.

5. PROPELLERS. Changes to propellers, such as minor variations in diameter, pitch, airfoil or planform, would normally be regarded as nonsignificant. Changes that are likely to have a marked effect on the integrity of the blades or the blade retention system, such as replacing metal blades with blades of composite construction or introducing different principles of blade retention, would generally be considered as significant. A change in the number of blades would normally be considered as a substantial change.

6. OTHER TYPE CERTIFICATED PRODUCTS. The principles already described in paragraphs 2 through 5 above should also be related to other aeronautical products, as appropriate. These would include airships, balloons, etc.

APPENDIX 2 - SAFETY BENEFIT-RESOURCE EVALUATION

1. PURPOSE: This appendix is included in the AC for information purposes. It describes a process that was developed with the intention of using it to determine the practicability of complying with later regulations of changed products, in accordance with § 21.101(b)(3), as amended by Amendment 21-XX. The charts included in the guide may be useful as an estimation technique but may not be used, in and of themselves, to determine the practicability of compliance.

2. BACKGROUND: Amendment 21-XX resulted, in part, from a recommendation from the Aviation Rulemaking Advisory Committee (ARAC). The working group that supported the ARAC in this project developed a safety benefit-resource evaluation guide. It was intended that this guide be used to determine when compliance with a later amendment of an airworthiness regulation would be impractical.

The procedure combines two indices to arrive at an indication of the impact of implementing a later airworthiness regulation. The "safety index" was intended to address the degree of exposure to an accident or incident; it was intended to reflect the effectiveness of the later amendment to deal with the exposure. The "resource index" was intended to address the resources involved in complying with the later amendment; it was intended to include factors representing the total cost to society for air transportation.

Although the FAA has not adopted the ARAC recommended procedure as a means of compliance, it does describe many of the issues that an applicant for a change and the FAA would need to consider; thus, the procedure is reproduced in paragraphs 3 through 5 of this appendix for information purposes.

3. INSTRUCTIONS FOR DEVELOPING THE CHARTS

An applicant using a "safety benefit-resource evaluation guide" to develop his arguments concerning practicability would need to develop his own charts and graphs,

and demonstrate how the numbers, slopes, and values support the determination of practicability. The FAA would approve the applicant's proposed certification basis if it determines that the applicant's procedure demonstrates compliance with § 21.101(b)(3).

The data base for accidents and incidents should include all aircraft affected by the airworthiness regulation in question. Additionally, the length of the production run should not be a consideration in the development of the "resource index" as every applicant for the same alteration to the same product should have to comply with the same regulations.

For the procedure presented in this example, the points on the charts represent the mean derived from the experience of a number of engineers that have been involved in certification programs. The numbers on the charts were adjusted to reflect a review of several alterations of transport category airplanes with respect to the revisions of part 25.

a. Safety Index. The "safety index" is a function of:

(1) The seriousness of the consequences of the hazard that the regulatory revision addresses;

(2) The frequency of those consequences; and

(3) The effectiveness of applying to the changed product the regulatory revision intended to address this hazard.

b. Resource Index. The "resource index" is a function of:

(1) The extent of labor required to comply with the regulatory revision.

(2) The extend of new capital equipment needed;

(3) The impact on scrap, part interchangeability, and the need for new aircraft equipment;

(4) The potential increase in operating cost; and

(5) The revenue/utility loss resulting from the implementation of the regulatory revision.

4. INSTRUCTIONS FOR DEVELOPING THE ANALYSIS.

a. Chart. The applicant would have to develop a chart, similar to the one shown, that would accommodate the following steps which appear necessary.

b. Upper Portion of the Chart.

(1) Identify the regulatory revision being evaluated;

(2) Identify the specific hazard that the regulatory revision addressed;

(3) Review the history (data base of accidents and incidents of all aircraft affected by the regulatory revision being addressed) of the consequences of the hazard that led to the regulatory revision - i.e:

(i) Caused injuries; and/or
(ii) Resulted in a hull loss but no deaths; and/or
(iii) Resulted in deaths of less than 10% of the people on board; and/or
(iv) Resulted in deaths of more than 10% of the people on board.

Note: A hazard may have had more than one of these consequences.

(4) The results of the history review for each consequence should be plotted in the upper left-hand quadrant of the chart; and

(5) The "longest" vector is transferred to the upper right-hand quadrant of the chart and an estimate made of the effectiveness of the regulatory revision.

Note: The effectiveness of an action is a direct function of the precision of the hazard statement in step 4.b. (2) and of the design features of the changed product. Table 2.1, Descriptions for Effectiveness of Actions, provides suggested descriptions for effectiveness of actions for the subjective judgments of the effectiveness of the regulatory revision.

c. Lower Portion of the Chart. The lower left-hand part of the chart provides a method to determine the economic effect of the action proposed to comply with the regulatory revision. It is not intended to be a detailed cost benefit study, but rather to determine if the regulatory revision should be implemented. This is accomplished by determining the impact of the proposed action on each of the resource categories. Five categories have been suggested that apply to transport category airplanes used in air commerce, and are Labor, Capital, Material, Operating Cost, and Revenue or Utility Loss. The applicant would have to develop values for these categories or similar categories of his own choosing. The following steps are required to use the lower portion of the chart:

(1) Assess each of the categories as defined in Table 2.2, Resource Definitions. This table also gives a description of the scope of each of the categories; and

(2) Determine the "resource index" for a proposed action, which is a result of adding the points from each of the five resource categories.

d. Combined Portions of the Chart. The "safety index" and RESOURCE INDEX are then combined on the lower right-hand quadrant of the chart to determine if the

proposed action is appropriate. If the evaluation of the proposed action clearly falls on the "effective" side of the lower right-hand quadrant of the chart, the amendment considered should be incorporated into the certification basis. If the evaluation of the proposed action clearly falls on the "not effective" side of the lower right-hand quadrant of the chart, the amendment may not need to be incorporated into the certification basis. However, if the evaluation of the proposed action falls any where near the "marginal" part of the chart, this method is not definitive, and other methods of evaluation should be considered.

5. EXAMPLE. Figure 2.1 illustrates the use of the "safety benefit-resource evaluation guide" for an unspecified hazard.

Table 2.1 - DESCRIPTIONS FOR EFFECTIVENESS OF ACTIONS		
Level I	**Eliminates hazard or allows hazard to be completely avoided.**	**Action is fully effective in all cases.**
Level II	**Considerable potential for eliminating or avoiding the hazard.**	**Action is fully effective in all probable or likely cases, but does not cover all situations or scenarios.**
Level III	**Adequately deals with the hazard.**	**Action is fully effective in many cases, but does not cover all probable or likely cases. Usually this action only addresses a significant part of a larger or broader hazard.**
Level IV	**Hazard only partly addressed.**	**Action is partly effective in some cases, but does not cover all probable or likely cases. Usually this action only addresses part of a hazard.**
Level V	**Hazard only partly addressed but action has negative side effect.**	**Action is of questionable benefit.**

Terms used in Table 2.2

Labor is work carried out in the design, fabrication, inspection, operation or maintenance of an aircraft for the purpose of incorporating or demonstrating compliance with a proposed action. Non-recurring and recurring labor requirements, including training, will be considered.

Capital is construction of new, modified or temporary facilities for design, production, tooling, training or maintenance.

Material is costs associated with product materials, product components, inventory, kits and spares.

Operating Costs are only associated with fuel, oil, fees and expendables (such as de-icing fluids).

Revenue/Utility Loss results from earning/usage capability reductions from departure delays, product downtime, capability reductions or performance loss due to seats, cargo, range or airport restrictions.

Table 2.2 - RESOURCE DEFINITIONS

	1 Point	4 Points	20 Points	100 Points
Labor	Negligible increase in man hours required.	Increase in man hours required. Basic labor requirement may be accomplished by existing workforce.	Significant increase in man hours required,resulting in an increased workforce.	Substantial increase in man hours, requiring a workforce that may not be available.
Capital	No requirement for any new or modified facilities or capital equipment.	Requires minor modification to existing facilities or equipment. Minor investment in equipment may be required.	Requires minor investment in new facilities or significant modification of existing facilities, or significant investment in equipment.	Requires substantial investment in new or modified facilities or equipment.
Materials	Negligible effect on product components, interchangeability or rework.	Minor design or construction changes which may result in reworking existing components. Relatively minor expenditures in aircraft equipment may be required.	Changes that effect interchangeability of replaceable components and/or which may require significant scrappage of components. Relatively significant expenditures in aircraft equipment may be required.	Changes to design or construction of product which results in very significant level of scrap. Relatively substantial expenditures in aircraft equipment amy be required.
Operating Cost Increase	Negligible change.	Minor (>0.4% for commercial operation)	Significant (>2.0% for commercial operation)	Substantial (>4.0% for commercial operation)
Revenue or Utility Loss	Negligible change.	Minor (>0.1% for commercial operation)	Significant (>0.5% for commercial operation)	Substantial (>1.0% for commercial operation)

Figure 2.1

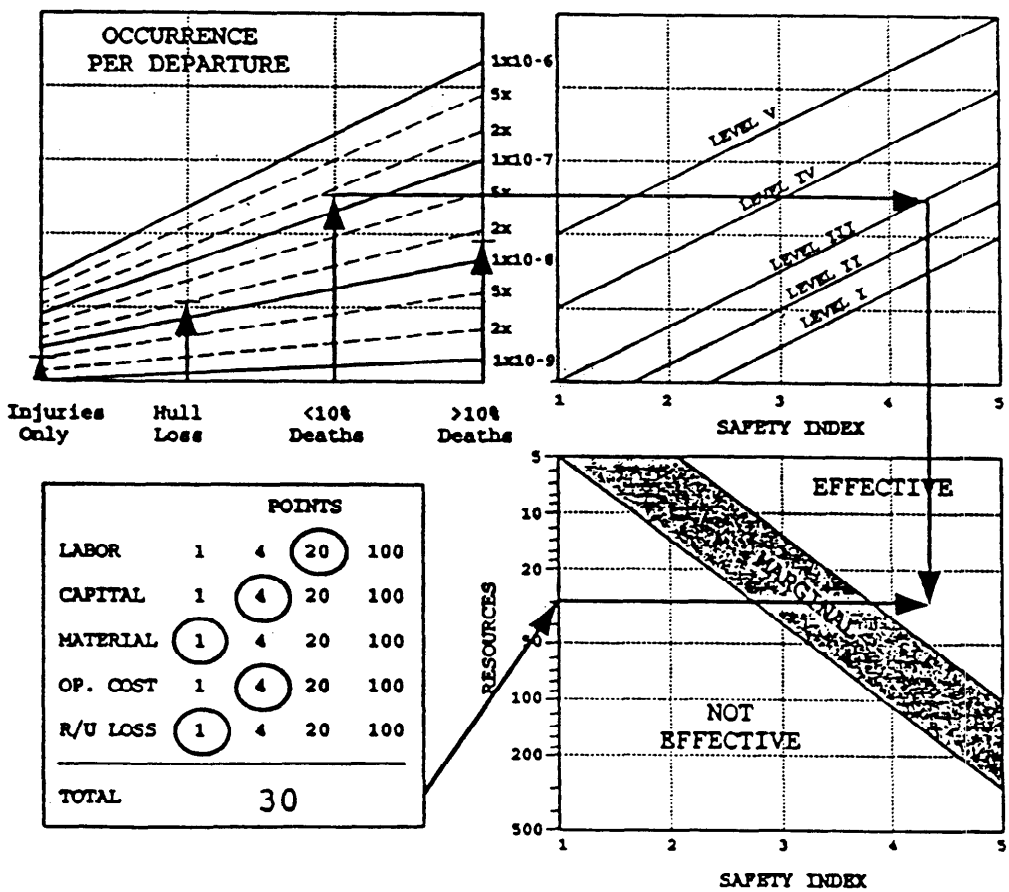
EXAMPLE TO ILLUSTRATE USE OF THE SAFETY/RESOURCE EVALUATION GUIDE.

1. Regulation:

FAR XX.YYY Amendment XX-ZZ

2. Hazard addressed:

Description of the Hazard addressed and specifically how the regulatory change reduces the hazard.



APPENDIX 3 - EXAMPLE OF SERVICE EXPERIENCE BEING USED FOR EVALUATING THE CERTIFICATION BASIS FOR A CHANGED PRODUCT

1. INTRODUCTION. Service experience may be used to assist in evaluating the certification basis for a changed product. The proposed certification basis may be used when the applicant shows that the design's compliance with the proposed certification basis, as evidenced by the applicable service experience, provides a level of safety similar to that expected by compliance with the later airworthiness regulations. A numerical/statistical approach may be used, subject to the availability and relevance of data, however sound engineering judgment must be used. The essentials of the process involve:

a. A clear understanding of the rule change and what prompted the change;

b. A determination based on detailed knowledge of the proposed design feature; and

c. A comprehensive review of the service experience.

d. If compliance with the later airworthiness regulations entails a design change, the benefits of such a redesign would be considered in the light of any possible adverse effects of the redesign on operation, reliability, durability, etc.

2. GUIDELINES. The issue paper procedures would be used, and the applicant should provide documentation to support the following:

a. Regulatory Differences. The identification of the differences between the regulation in the existing certification basis and the regulation as amended, and the effect of these differences.

b. Loss of Good Experience. Evidence that complying with the later regulation will not enhance safety sufficiently to compensate for the loss of good experience with a well proven/tested system, part, or component.

c. Design Feature. A description of the design feature and its intended function.

d. Data Analysis.

(1) Identification of the service experience from such sources as:

(i) Accidents;
(ii) Incidents;
(iii) Service Bulletins;
(iv) Airworthiness Directives;
(v) Repairs;
(vi) Alterations;
(vii) Flight hours/cycles for fleet leader and total fleet;
(viii) World Airline Accident Summary (WAAS) Data;
(ix) Service Difficulty Reports; and
(x) N.T.S.B. Reports.

(2) Show that the data presented represents all relevant service experience for the product, including the results of any operator surveys.

(3) Show that the service experience is relevant to the issue.

(4) Identification and evaluation of each of the main areas of concern relevant to each occurrence, with regard to:

(i) Recurring and/or common failure modes;
(ii) Cause;

(iii) Probability, by quantitative reasoning; and

(iv) Measures already taken and their effects.

(5) If relevant data are available for other types of aircraft, they may be included.

(6) Confirm understanding of failure modes and consequences through analytical processes. This may include:

(i) A review of previous test results; and

(ii) Additional detailed testing.

e. Conclusion. A conclusion that draws together the data and the rationale.

f. These guidelines are not intended to be limiting, either in setting required minimum elements or in precluding alternative forms of submission. Each case may be expected to be different, based on the particulars of the system being examined and the point to be made. Engineering judgment covers a very wide field which should not be limited in scope to service experience precedents which have previously been set.